APPENDIX A

PROCESS DESCRIPTION

CURRENT PROCESS

PRIMARY TREATMENT

C Bar Screen
• Metering Flume

SECONDARY TREATMENT

C Aeration lagoon (2)
C Aerated polishing pond
C Chlorine contact disinfection
• Dechlorination
C Flow measurement

The Palmer wastewater treatment process includes primary screening with further treatment by an aerated lagoon, followed by a polishing pond. The two aerated lagoons are operated in parallel to provide treatment for a maximum of 750,000 gallons per day. The lagoons are usually operated in series. Either lagoon in service provides a detention time of about 22 days prior to the polishing pond which provides another 24 days of detention time at the average flow rate of 300,000 gallons per day. Finally, the treated wastewater is chlorinated and de-chlorinated prior to discharge into the Matanuska River.

During periods of heavy rainfall or break-up, the influent flow rate increases about 20 to 30 percent. Infiltration and inflow (I&I) are systematically investigated and eliminated when possible. I&I is not a problem at this treatment facility. Influent values of BOD are typically around 250 mg/L.

The population of the City of Palmer has increased by approximately 1,500 since the issuance of the previous permit. The facility was upgraded in 1998 to accommodate the increase in population. The existing treatment system is fully adequate to serve the needs of the community beyond the life of the renewed permit, which will expire in 2005.

Figure A-1. Current Treatment Process Flow Diagram.

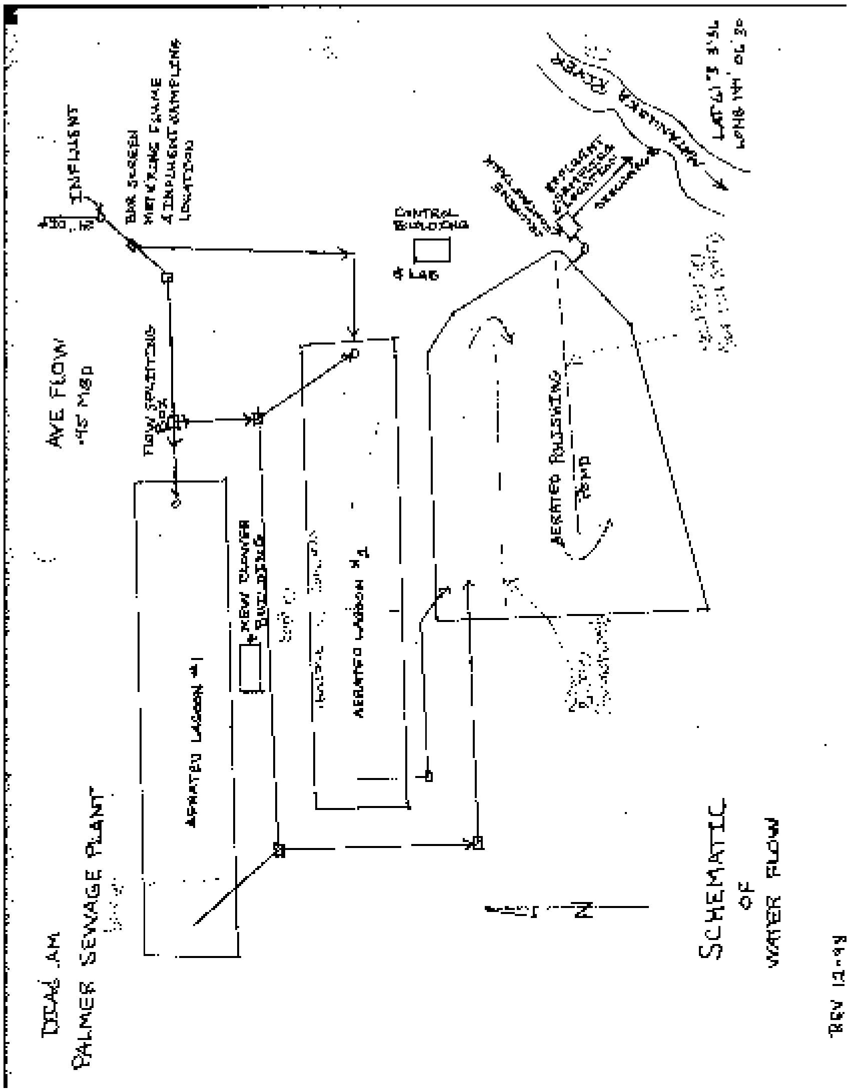
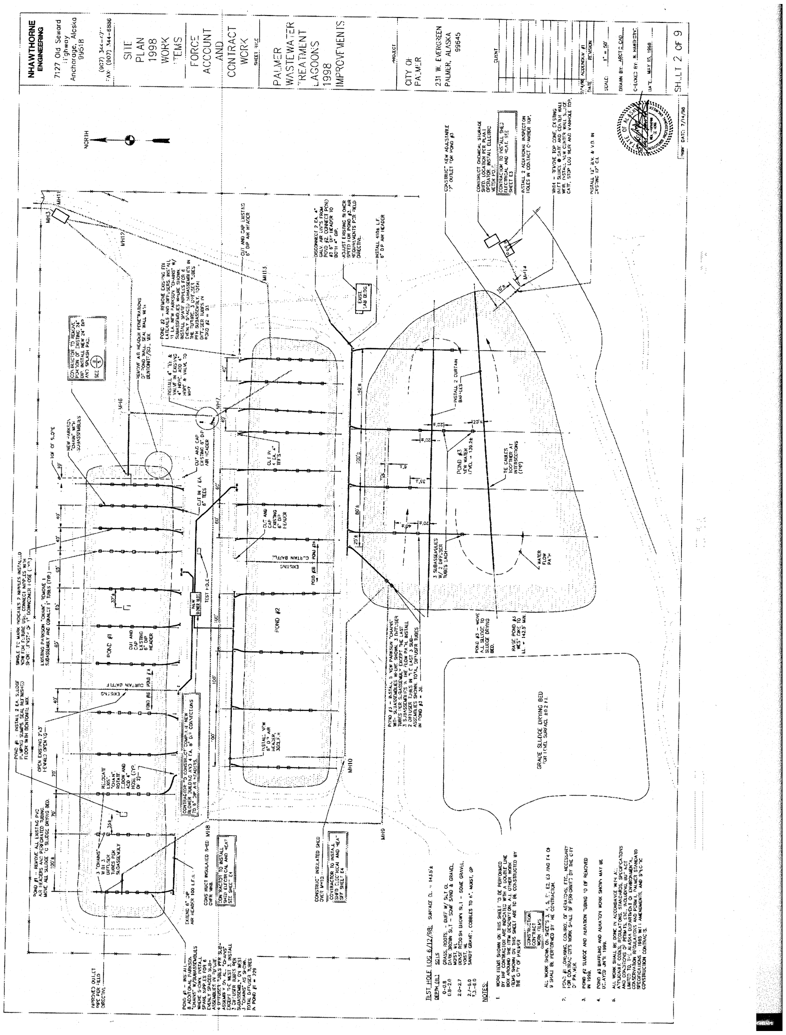


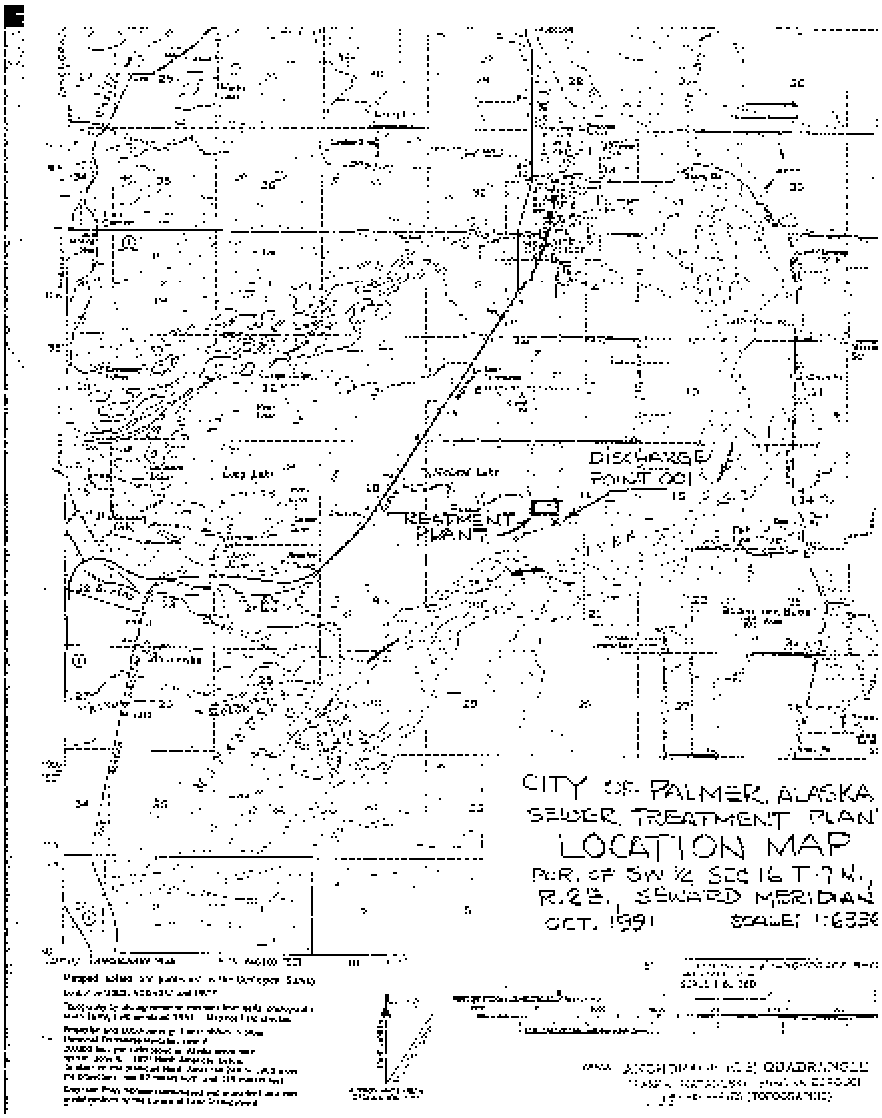
Figure A-2. Future Upgrades for City of Palmer WWTP.



APPENDIX B

FACILITY LOCATION MAP

Figure B-1. Location of City of Palmer WWTP.



APPENDIX C

CALCULATIONS

Calculations used to determine reasonable potential to violate water quality standards and develop permit limits were derived from EPA's Technical Support Document (EPA, 1991). This appendix is comprised of the following: Section 1 provides a discussion about the calculations used to determine reasonable potential, allocate a wasteload, develop permit limits, and determine sampling frequency; Section 2 cites the river flows used in the calculations; and Section 3 presents the calculations used in developing the limitations and monitoring frequencies in the draft permit.

SECTION 1: DISCUSSION OF CALCULATIONS

This section discusses the calculations used to determine reasonable potential, determine a wasteload allocation, and develop permit limits. In determining reasonable potential and water quality-based permit limits, EPA uses the steady-state model represented by the following equation:

$$Q_d C_d = Q_e C_e + Q_u C_u \qquad \text{[eqn. 1]}$$

where Q_d is the downstream receiving water flow (Q_e+Q_u), C_d is the downstream receiving water concentration, Q_e is the effluent flow, C_e is the effluent concentration, Q_u is the critical upstream receiving water flow with the allowed mixing, and C_u is the upstream receiving water concentration.

The critical upstream receiving water flow (Q_u) is dependant upon the critical flow and the allowed mixing:

$$Q_u = [critical \quad flow][allowed \quad mixing]. \qquad \text{[eqn. 2]}$$

The critical flows for the different criteria are: the 7Q10 flow is used when applying the chronic criterion, the 1Q10 is used when applying the acute criterion, the harmonic mean is used when applying the human health or agriculture carcinogenic criterion, and the 30Q5 is used when applying the human health or agriculture non-carcinogenic criterion.

The allowed mixing is a percent of the critical flow or a dilution ratio (dilution:1), where dilution is expressed as:

$$dilution = \frac{Q_d}{Q_e} = \frac{\left(Q_e + [critical \quad flow][allowed \quad mixing]\right)}{Q_e}. \qquad \text{[eqn. 3]}$$

Since the state of Alaska has not authorized a mixing zone, $Q_u = 0$ and equation 1 is expressed as:

$$Q_eC_d = Q_eC_e \qquad \text{[eqn. 4]}$$

DETERMINING REASONABLE POTENTIAL

Reasonable potential is determined when the projected downstream concentration exceeds a water quality criteria. If reasonable potential is determined, then a water quality based effluent limit is required. To determine if there is a reasonable potential to exceed a water quality criteria, equation 1 is rearranged to solve for the projected downstream receiving water concentration (C_d):

$$C_d = \frac{\left(Q_eC_e + Q_uC_u\right)}{Q_d}. \qquad \text{[eqn. 5]}$$

In equation 5, C_e is derived using EPA's statistical approach in the following equation:

$$C_e = MEC \times RPM \qquad \text{[eqn. 6]}$$

where MEC is the maximum effluent concentration, and RPM is the reasonable potential multiplier.

The RPM converts the MEC to the upper bounds of a lognormal distribution using a statistical analysis of the data set. The RPM is calculated in two parts. In the first part, the percentile (p_n) represented by the highest concentration in the data is computed using the following equation:

$$p_n = \left(1 - confidence\,level\right)^{1/n} \qquad \text{[eqn. 7]}$$

where the confidence level is 99 percent (0.99) and n is the number of data points. Then the reasonable potential multiplier (RPM) is determined from a relationship between the percentile and the selected upper bound of the lognormal effluent distribution. This relationship is given in the following equation:

$$RPM = \frac{C_{99}}{C_{p_n}} = \frac{\exp\left(2.326 \quad - 0.5s^{2}\right)}{\exp\left(zs - 0.5s^{2}\right)} \qquad \text{[eqn. 8]}$$

where C_{99} is the statistical variability at an upper bound of 99 percent, C_{pn} is the statistical variability at the percentile (p_n), z is the statistical z-score at the percentile, $F^2=\ln(CV^2+1)$, and CV is the ratio of the standard deviation to the mean. The RPM is then multiplied by the MEC to obtain the projected maximum value of effluent concentration (C_e):

$$C_e = MEC \cdot RPM \, . \qquad \text{[eqn. 9]}$$

Once C_e is determined, equation 5 can be used to project the downstream concentration (C_d) and compared to the criteria to determine if there may be an exceedance of the water quality standard.

DETERMINING A WASTELOAD ALLOCATION

The wasteload allocation (WLA) is used to determine the level of effluent concentration that would comply with water quality standards in the receiving water. A WLA is determined only for parameters that have a reasonable potential to cause an exceedance of water quality standards. The WLA for aquatic life provides two numbers for protection against two types of toxic effects: acute (WLA_a) and chronic (WLA_c). In contrast, there is only a chronic WLA for human health and agriculture. To determine WLAs, equation 1 is rearranged to solve for C_e:

$$WLA = C_e = \frac{C_d\left(Q_e + Q_u\right) - C_u Q_u}{Q_e} \, . \qquad \text{[eqn. 10]}$$

In equation 10, the numeric criteria in the water quality standards are used as the desired downstream concentration (Q_d) to calculate effluent concentrations that would result in compliance with those standards.

DERIVING A PERMIT LIMIT

AQUATIC LIFE

The WLA for aquatic life provides two numbers for protection against two types of toxic effects: acute and chronic. These requirements yield different effluent treatment requirements that cannot be compared to each other without calculating the long-term average (LTA) performance level the plant would need to maintain in order to meet each requirement. The acute LTA is calculated using the following equation:

$$LTA_{a,c} = WLA_a \cdot e^{[0.5s - zs]} \qquad \text{[eqn. 11]}$$

where $F^2=\ln(CV^2+1)$ and z=2.326 for the 99th percentile probability basis. Likewise, the chronic LTA is calculated as follows:

$$LTA_c = WLA_c \cdot e^{\left[0.5s_4{}^2 - zs_4\right]} \qquad \text{[eqn. 12]}$$

where $F_4{}^2=\ln(CV^2/4+1)$ and z=2.326 for the 99th percentile probability basis. Once the acute and chronic LTAs are computed, they are compared and the lowest one is selected for permit limit development since it is protective of both acute and chronic WLAs.

The NPDES regulations at 40 CFR Part 122.45(d) require that all permit limits be expressed, unless impracticable, as both average monthly limits (AMLs) and maximum daily limits (MDLs) for all discharges other than POTWs, and as average weekly limits (AWLs) and average monthly limits for POTWs. For acute toxicity impacts, EPA recommends establishing a maximum daily limit in lieu of an average weekly limit for POTWs because the federal regulations do not prohibit a permittee from increasing their sampling events above what is required in an NPDES permit. This is significant because a permittee may collect as many samples as necessary during a week to bring the average of the data set below the average weekly effluent limit. In such cases, spikes of a pollutant could be masked by the increased sampling. While this is not a concern with pollutants that are not toxic, such as total suspended solids or phosphorus, it is a significant concern when toxic pollutants, such as chlorine or ammonia, are being discharged. Using a maximum daily limit will ensure that spikes do not occur, and will be protective of aquatic life. In this case, an average weekly limit is not protective of water quality standards, therefore, it is impracticable to have it in the permit. Therefore, the maximum daily limit and average monthly limit are computed using the following equations:

$$MDL = LTA \cdot e^{\left[zs - 0.5s^2\right]} \qquad \text{[eqn. 13]}$$

$$AML = LTA \cdot e^{\left[zs_n - 0.5s_n^2\right]} \qquad \text{[eqn. 14]}$$

where F^2=ln(CV^2+1), F_n^2=ln(CV^2/n+1), n is the number of samples required per month, and z=1.645 for the 95th percentile probability basis.

Equations 13 and 14 provide limits based on concentration, however the NPDES regulations at 40 CFR Part 122.45(f) require that all pollutants limited in permits shall have limitations expressed in terms of mass except for pH, temperature, radiation, or other pollutants which cannot appropriately be expressed by mass. Thus, the MDL and AML must be converted to mass loadings, when applicable, as follows:

Maximum Daily Loading = MDL·Q_e·8.34 (lb/day) [eqn. 15]

Average Monthly Loading = AML·Q_e·8.34 (lb/day) [eqn. 16]

where Q_e is in units of million gallons per day (mgd) and 8.34 is a conversion factor.

HUMAN HEALTH & AGRICULTURE

Determining permit limits for pollutants affecting human health is somewhat different from setting limits for other pollutants because the exposure period is generally longer than one month. If the procedures used for aquatic life protection were applied in the development of permit limits for human health pollutants, both MDLs and AMLs would exceed the WLA. Therefore, the AML is set equal to the WLA and the MDL is computed as follows:

$$MDL = AML \cdot \frac{e^{\left[z_m s - 0.5s^2\right]}}{e^{\left[z_a s_n - 0.5s_n^2\right]}} \qquad \text{[eqn. 17]}$$

where F^2=ln(CV^2+1), F_n^2=ln(CV^2/n+1), n is the number of samples required per month, z_m=2.326 for the 99th percentile probability basis, and z_a=1.645 for the 95th percentile probability basis. The MDL and AML are then converted to mass loadings, when appropriate, using equations 15 and 16.

SECTION 2: FLOW CONDITIONS

The flows used to evaluate compliance with the criteria are:

- The 1 day, 10 year low flow (1Q10) is used for the protection of aquatic life from acute effects. It represents the lowest daily flow that is expected to occur once in 10 years.

- The 7 day, 10 year low flow (7Q10) is used for the protection of aquatic life from chronic effects. It the lowest 7 day average flow expected to occur once in 10 years.

- The 30 day, 5 year low flow (30Q5) is used for the protection of human health from non-carcinogens. It represents the 30 day average flow expected to occur once in 5 years.

- The harmonic mean flow is a long-term average flow and is used for the protection of human health from carcinogens. It is the number of daily flow measurements divided by the sum of the reciprocals of the flows. The harmonic mean was also used for the protection of agriculture year round.

The following table provides the flow information from the USGS gaging station at Palmer that was used for reasonable potential analysis:

1Q10 (cfs)	7Q10 (cfs)	30Q5 (cfs)	Harmonic Mean (cfs)
348	349	360	1,026

SECTION 3: CALCULATIONS

Silver

Step 1. Is there reasonable potential to exceed water quality standards?

$\mathbf{C_d=(Q_eC_e+Q_uC_u)\div(Q_e+Q_u)}$

A. Acute Aquatic Life

criterion: e^{1.72[ln(hardness)]-6.52}=8.34 µg/L
hardness = 152 mg/L
maximum reported value (MRV) = 15.8 µg/L
number of data points (n) = 44
percentile based on 99% confidence level (p_n) = $(1-.99)^{1/n}$ = 0.9006
z-score for percentile (z) = 1.28
coefficient of variation (CV) = (standard deviation ÷ mean) = 0.5
$F^2 = \ln(CV^2+1) = 0.22$
F = 0.47
reasonable potential multiplier (RPM) = $\frac{c_{99}}{c_{87}} = \frac{\exp(2.326s - 0.5s^2)}{\exp(zs - 0.5s^2)}$ =1.63
maximum projected effluent concentration (Ce) = (MRV)(RPM) = 25.8 µg/L
Q_e = 0.75 mgd
Q_u = 1Q10 * dilution = 32 mgd
1Q10 = 70 cfs = 45 mgd
dilution = 72% (43:1)
C_u = 0 µg/L (unknown, thus assume zero)
receiving water concentration (C_d) = [(0.75)(25.8)+(32)(0)]÷(0.75+32) = 0.6 µg/L

0.6 µg/L < 8.34 µg/L (WQS: acute criterion)

Since the projected downstream concentration does not exceed the criterion, limits are not needed at the end of the pipe.

B. Human Health

criterion: 50 µg/L
maximum reported value (MRV) = 15.8 µg/L
number of data points (n) = 44
percentile based on 99% confidence level (p_n) = $(1-.99)^{1/n}$ = 0.9006
z-score for percentile (z) = 1.28
coefficient of variation (CV) = (standard deviation ÷ mean) = 0.5
$F^2 = \ln(CV^2+1) = 0.22$
F = 0.47

reasonable potential multiplier (RPM) = $\frac{c_{99}}{c_{87}} = \frac{\exp\left(2.326s - 0.5s^2\right)}{\exp\left(zs - 0.5s^2\right)} = 1.63$

maximum projected effluent concentration (Ce) = (MRV)(RPM) = 25.8 µg/L
Q_e = 0.75 mgd
Q_u = 30Q5 * dilution = 0 mgd
    30Q5 = 72 cfs = 45 mgd
    dilution = 0% (0.0)
C_u = 0 µg/L (unknown, thus assume zero)
receiving water concentration (C_d) = [(0.75)(25.8)+(0)(0)]÷(0.75+0) = 25.8 µg/L

25.8 µg/L < 50 µg/L (WQS: human health criterion)

Since the projected downstream concentration does not exceed the criterion, limits are not needed for human health.

C. Drinking Water

criterion: 100 µg/L
maximum reported value (MRV) = 15.8 µg/L
number of data points (n) = 44
percentile based on 99% confidence level (p_n) = $(1-.99)^{1/n}$ = 0.9006
z-score for percentile (z) = 1.28
coefficient of variation (CV) = (standard deviation ÷ mean) = 0.5
$F^2 = \ln(CV^2+1) = 0.22$
$F = 0.47$
reasonable potential multiplier (RPM) = $\frac{c_{99}}{c_{87}} = \frac{\exp(2.326s - 0.5s^2)}{\exp(zs - 0.5s^2)}$ =1.63
maximum projected effluent concentration (Ce) = (MRV)(RPM) = 25.8 µg/L
Q_e = 0.75 mgd
Q_u = 3Q5 * dilution = 0 mgd
30Q5 = 72 cfs = 45 mgd
dilution = 0% (0.0)
C_u = 0 µg/L (unknown, thus assume zero)
receiving water concentration (C_d) = [(0.75)(25.8)+(0)(0)]÷(0.75+0) = 25.8 µg/L

16.2 µg/L < 100 µg/L (WQS: acute criterion)

Since the projected downstream concentration does not exceed the criterion, limits are not needed for drinking water.

Ammonia

Step 1. Is there reasonable potential to exceed water quality standards?

$\mathbf{C_d=(Q_eC_e+Q_uC_u)\div(Q_e+Q_u)}$

A. Acute Aquatic Life

criterion: 5.3 mg/L
pH = 8.15, Temp. = 10EC, cold water species present
maximum reported value (MRV) = 45.4 mg/L
number of data points (n) = 64
percentile based on 99% confidence level (p_n) = $(1-.99)^{1/n}$ = 0.9306
z-score for percentile (z) = 1.48
coefficient of variation (CV) = (standard deviation ÷ mean) = 0.6
$F^2 = \ln(CV^2+1) = 0.31$
F = 0.55

reasonable potential multiplier (RPM) = $\dfrac{c_{99}}{c_{87}} = \dfrac{\exp(2.326s - 0.5s^2)}{\exp(zs - 0.5s^2)}$ =1.6

maximum projected effluent concentration (Ce) = (MRV)(RPM) = 45.4 mg/L
Q_e = 0.75 mgd
Q_u = 1Q10 * dilution = 32 mgd
1Q10 = 70 cfs = 45 mgd
dilution = 72% (43:1)
C_u = 0 µg/L (unknown, thus assume zero)
receiving water concentration (C_d) = [(0.75)(45.4)+(32)(0)]÷(0.75+32) = 1.0 mg/L

1.0 mg/L < 5.3 mg/L (WQS: acute criterion)

Since the projected downstream concentration does not exceed the criterion, limits are not needed at the end of the pipe.

B. Chronic Aquatic Life

criterion: 1.02 mg/L

pH = 8.15, Temp. = 10EC, cold water species present

number of data points (n) = 64

percentile based on 99% confidence level (p_n) = $(1-.99)^{1/n}$ = 0.9306

z-score for percentile (z) = 1.48

coefficient of variation (CV) = (standard deviation ÷ mean) = 0.6

$F^2 = \ln(CV^2+1) = 0.31$

F = 0.55

reasonable potential multiplier (RPM) = $\frac{C_{99}}{C_{87}} = \frac{\exp(2.326s - 0.5s^2)}{\exp(zs - 0.5s^2)}$ =1.6

maximum projected effluent concentration (Ce) = (MRV)(RPM) = 45.4 mg/L

Q_e = 0.75 mgd

Q_u = 7Q10 * dilution = 32 mgd

7Q10 = 70 cfs = 45 mgd

dilution = 72% (43:1)

C_u = 0 µg/L (unknown, thus assume zero)

receiving water concentration (C_d) = [(0.75)(45.4)+(32)(0)]÷(0.75+32) = 1.04 mg/L

1.04 mg/L > 1.02 mg/L (WQS: chronic criterion)

Since the projected downstream concentration exceeds the criterion, limits are needed and applied at the end of the pipe.

Step 2. Calculate Waste Load Allocations (WLAs) for each criterion

$WLA=C_e = [C_d(Q_e+Q_u)-Q_uC_u]\div Q_e$

Acute Aquatic Life	$WLA_{a,c}$ = [(5.3)(0.75+32)-(32)(0)]÷0.75 = 230 mg/L
Chronic Aquatic Life	WLA_c = [(1.02)(0.75+32)-(32)(0)]÷0.75 = 44 mg/L

Step 3. Calculate effluent limitations for Aquatic Life

1. Long-term Average (LTA)

   a. Acute LTA

   $LTA_{a,c} = WLA_{a,c} \cdot \exp[0.5F^2 - zF]$
   z (for 99th percentile) = 2.326
   $LTA_{a,c} = 230 \cdot \exp[(0.5)(0.31) - (2.326)(0.55)]$
   $LTA_{a,c} = 75$

   b. Chronic LTA

   $LTA_c = WLA_c \cdot \exp[0.5F_4^2 - zF_4]$
   z (for 99th percentile) = 2.326
   $F_4^2 = \ln[(CV^2 \div 4) + 1] = 0.07$
   $F_4 = 0.29$
   $LTA_c = 44 \cdot \exp[(0.5)(0.07) - (2.326)(0.29)]$
   $LTA_c = 23$

   Lowest LTA = 23

2. Maximum Daily Limit (MDL) and Average Monthly Limit (AML)

   MDL $= LTA \cdot \exp[zF - 0.5F^2]$
   z (for 99th percentile) = 2.326
   $= 23 \cdot \exp[(2.326)(0.55) - (0.5)(0.31)]$
   = <u>71 mg/L</u>

   AML $= LTA \cdot \exp[zF_n - 0.5F_n^2]$
   z (for 95th percentile) = 1.645
   $F_n^2 = \ln[CV^2/n+1] = 0.08$
   number of samples/month (n) = 4
   $F_n = 0.27$
   $= 23 \cdot \exp[(1.645)(0.27) - (0.5)(0.08)]$
   = <u>34 mg/L</u>

Step 4. Calculate Loadings

MDL $= (C_{MDL})(Q_e)(8.34) = (71)(0.75)(8.34) =$ 430 lbs/day
AML $= (C_{AML})(Q_e)(8.34) = (34)(0.75)(8.34) =$ 200 lbs/day

Step 5. Determine Monitoring Frequency

Goal: Want % chance of violating permit limit to be greater than 75% ($\$ < 0.3$).

Using the Power test and t-distribution:

$$n = s^2 \div *^2 \cdot (t_{"(1),<} + t_{\$(1),<})^2$$

Calculate # Samples:

n_{guess} = number of samples per month = 5
s = the sample standard deviation = 11.93
* = *the mean of existing data - the average monthly limit* = *6.4- 4.5* = 20.3
"(1) = (1 - p_n) ÷ 2 (for a one-tailed test) = (1 - .93) ÷ 2 = 0.025
< = n_{guess} - 1 = 4
$t_{"(1),<}$ = 2.776 (t-distribution table)
$t_{\$(1),<}$ = 0.741 (t-distribution table)
n = $2.96^2 \div 1.9^2 \cdot (2.776 + 0.741)^2$ = 4

Since n > n_{guess} and there are no integer numbers between 4 and 5, a sample size of at least 5 per month is required.

Total Residual Chlorine

Step 1. Is there reasonable potential to exceed water quality standards?

$\mathbf{C_d=(Q_eC_e+Q_uC_u)\div(Q_e+Q_u)}$

A. Acute Aquatic Life

criterion: 19 µg/L
maximum reported value (MRV) = 1,100 µg/L
number of data points (n) = 249
percentile based on 99% confidence level (p_n) = $(1\text{-}.99)^{1/n}$ = 0.9817
z-score for percentile (z) = 2.09
coefficient of variation (CV) = (standard deviation ÷ mean) = 0.6
$F^2 = \ln(CV^2+1) = 0.31$
$F = 0.55$
reasonable potential multiplier (RPM) = $\dfrac{c_{99}}{c_{87}} = \dfrac{\exp(2.326s - 0.5s^2)}{\exp(zs - 0.5s^2)}$ =1.1
maximum projected effluent concentration (Ce) = (MRV)(RPM) = 1,210 µg/L
Q_e = 0.75 mgd
Q_u = 1Q10 * dilution = 0 mgd
  1Q10 = 70 cfs = 45 mgd
  dilution = 0% (0:1)
C_u = 0 µg/L (unknown, thus assume zero)
receiving water concentration (C_d) = [(0.75)(1,210)+(0)(0)]÷(0.75+0) = 1,210 µg/L

1,210 µg/L > 19 µg/L (WQS: acute criterion)

Since the projected downstream concentration exceeds the criterion, limits are needed and applied at the end of the pipe.

B. Chronic Aquatic Life

criterion: 2 µg/L
maximum reported value (MRV) = 1,100 µg/L
number of data points (n) = 249
percentile based on 99% confidence level (p_n) = $(1-.99)^{1/n}$ = 0.9817
z-score for percentile (z) = 2.09
coefficient of variation (CV) = (standard deviation ÷ mean) = 0.6
$F^2 = \ln(CV^2+1) = 0.31$
$F = 0.55$
reasonable potential multiplier (RPM) = $\frac{c_{99}}{c_{87}} = \frac{\exp(2.326s - 0.5s^2)}{\exp(zs - 0.5s^2)}$ =1.1
maximum projected effluent concentration (Ce) = (MRV)(RPM) = 1,210 µg/L
Q_e = 0.75 mgd
Q_u = 7Q10 * dilution = 0 mgd
    7Q10 = 70 cfs = 45 mgd
    dilution = 0% (0:1)
C_u = 0 µg/L (unknown, thus assume zero)
receiving water concentration (C_d) = [(0.75)(1,210)+(0)(0)]÷(0.75+0) = 1,210 µg/L

1,210 µg/L > 2 µg/L (WQS: acute criterion)

Since the projected downstream concentration exceeds the criterion, limits are needed and applied at the end of the pipe.

Step 2. Calculate Waste Load Allocations (WLAs) for each criterion

$\mathbf{WLA=C_e = [C_d(Q_e+Q_u)-Q_uC_u]\div Q_e}$

Acute Aquatic Life	$WLA_{a,c}$ = [(19)(0.75+32)-(0)(0)]÷0.75 = 19 µg/L
Chronic Aquatic Life	WLA_c = [(2)(0.75+32)-(0)(0)]÷0.75 = 2 µg/L

Step 3. Calculate effluent limitations

A. Aquatic Life

1. Long-term Average (LTA)

a. Acute LTA

$LTA_{a,c} = WLA_{a,c} \cdot \exp[0.5F^2 - zF]$
z (for 99th percentile) = 2.326
$LTA_{a,c} = 19 \cdot \exp[(0.5)(0.31) - (2.326)(0.55)]$
$LTA_{a,c} = 6.2$

b. Chronic LTA

$LTA_c = WLA_c \cdot \exp[0.5F_4^2 - zF_4]$
z (for 99th percentile) = 2.326
$F_4^2 = \ln[(CV^2 \div 4) + 1] = 0.09$
$F = 0.29$
$LTA_c = 2 \cdot \exp[(0.5)(0.09) - (2.326)(0.29)]$
$LTA_c = 1.1$

Lowest LTA = 1.1

2. Maximum Daily Limit (MDL) and Average Monthly Limit (AML)

MDL $= LTA \cdot \exp[zF - 0.5F^2]$
z (for 99th percentile) = 2.326
$= 1.1 \cdot \exp[(2.326)(0.55) - (0.5)(0.31)]$
= <u>3.4 µg/L</u>

AML $= LTA \cdot \exp[zF_n - 0.5F_n^2]$
z (for 95th percentile) = 1.645
$F_n^2 = \ln[(CV^2 \div n) + 1] = 0.09$
number of samples/month (n) = 4
$F_n = 0.29$
$= 1.1 \cdot \exp[(1.645)(0.29) - (0.5)(0.09)]$
= <u>1.7 µg/L</u>

Step 4. Calculate Loadings

MDL = $(C_{MDL})(Q_e)(8.34)$ = (0.0034)(0.75)(8.34) = <u>0.02 lbs/day</u>
AML = $(C_{AML})(Q_e)(8.34)$ = (0.0017)(0.75)(8.34) = <u>0.01 lbs/day</u>

Step 5. Determine Monitoring Frequency

Goal: Want % chance of violating permit limit to be greater than 75% ($\$ < 0.3$).

Using the Power test and t-distribution:

$n = s^2 \div *^2$ ✎ $(t_{"(1),<} + t_{\$(1),<})^2$

Calculate # Samples:

n_{guess} = number of samples per month = 7
s = the sample standard deviation = 0.25
* = *the mean of existing data - the average monthly limit* = *6.4- 4.5* = 0.41
"(1) = (1 - p_n) ÷ 2 (for a one-tailed test) = (1 - .93) ÷ 2 = 0.01
< = n_{guess} - 1 = 6
$t_{"(1),<}$ = 3.143 (t-distribution table)
$t_{\$(1),<}$ = 0.718 (t-distribution table)
$n = 2.96^2 \div 1.9^2$ ✎ $(3.143 + 0.718)^2 = 6$

Since n > n_{guess} and there are no integer numbers between 6 and 7, a sample size of at least 7 per month is required.